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THE DISTRIBUTION OF MEDIUM AND HIGH CLOUD NEAR THE JET STREAMS

By J. S. SAWYER, M.A. and B. ILETT

Introduction.—Narrow belts of strong winds are a recognized feature of synoptic charts for levels in the upper troposphere* and have come to be known as "jet streams". The best defined maxima of wind appear to occur in relatively straight stretches of the meandering belt of the upper westerly current of the hemisphere. These narrow bands of strong upper winds persist from one chart to the next and must form stable dynamical systems. It might therefore be expected that features of the flow in the upper troposphere and associated cloud systems would show a closer relation to the position and movement of the axis of the jet stream than to the synoptic systems of the surface pressure field.

An investigation was undertaken recently at the Central Forecasting Office, Dunstable, in order to ascertain whether the distribution of medium and high cloud near the jet stream followed a recognizable pattern. If such a pattern existed it would be of value in the analysis of high-level charts when few upper air soundings were available; it might also permit the navigator of an aircraft to recognize his position with respect to the jet stream from the state of the sky.

The available data consisted of the synoptic reports received at the Central Forecasting Office (both surface observations and upper air soundings) together with the analysed charts. On the basis of these observations some uncertainty exists regarding the position of the axis of the jet stream; even over the British Isles it would not be expected that one could place the axis with a much smaller error than 200 miles the average distance between upper soundings; in other areas the errors would be greater. A less obvious uncertainty arises from reports of medium and high cloud. The estimation of the amount of high cloud is not easy, more especially when low cloud is also present; nor is the classification of the medium and high clouds according to the international codes entirely unambiguous. No doubt cirrus and medium cloud structures vary considerably from place to place, but reported amounts and types differ between stations so close together that the observers must be viewing the same clouds over at least part of the sky.

For these reasons it seemed unlikely that a direct examination of synoptic charts would give a true picture of the distribution of upper cloud around the

*DURST, C. S. and DAVIS, N. E.; Jet streams and their importance to air navigation. *J. Inst. Navig., London*, **2**, 1949, p. 210.

jet stream on individual occasions. A complete and accurate picture of the cloud distribution round any particular jet stream could only be obtained by a specially organized network of ground and air observations. It was therefore necessary to adopt a statistical approach in the hope that any relationships between cloud and jet stream, which are sufficiently regular to be of interest, would be brought out statistically despite errors and deficiencies in individual cases.

Method of analysis.—The period covered by the analysis was the year 1949. Occasions of jet streams passing over or within about 500 miles of the British Isles were noted by examination of the 300-mb. contour charts drawn regularly at the Central Forecasting Office. For this purpose a belt of approximately straight flow with a maximum wind speed (observed or geostrophic) at 300 mb. of 70 kt. or more was taken as defining a "jet stream". However, in order to see if the chosen lower limit of velocity had any effect on the results, the statistical analysis was also completed separately for those cases in which the wind speed exceeded 120 kt. The axis of the jet stream, that is the line of greatest velocity, was noted on the charts for 1500 G.M.T. each day, and the distribution of medium and high cloud examined in relation to this.

All available observations of medium and high cloud for 1500 G.M.T. were analysed in relation to their position with respect to the axis of the jet stream. The present scheme of synoptic reporting does not make provision for reports of the amount of the medium and high cloud layers on all occasions. However, an estimate of the amount of both medium and high cloud was made on the basis of the total amount of cloud reported and the amounts reported in lower cloud layers. For this purpose it was assumed that the same proportion of the whole sky was covered by medium and high cloud as in the part of the sky visible through the low cloud. If the amount of low cloud was less than 4 oktas and no upper cloud was reported both cirrus and medium cloud were assumed to be absent. Occasions of 4 oktas of low cloud or more and no medium cloud or cirrus observed were not included in the statistical summaries.

Statistical results.—In order to analyse the distribution of cloud in relation to the axis of the jet stream, the area round the jet stream was divided into eight sectors as indicated in Fig. 1. The area was divided first into bands parallel to the jet stream and 200 miles wide, and secondly by a line perpendicular to the axis through its mid point, dividing the jet stream into two equal sections longitudinally from the entrance to the mid point and from the mid point to the exit. The letters in Fig. 1 have been used to define the sectors in the tabular results.

The results of the statistical analysis is given in Tables I and II. The number of occasions of particular amounts and types of medium and high cloud is expressed as a percentage of the number of occasions for which observations of medium and high cloud respectively or their absences were available in the particular sectors. It must be remembered in considering these figures that observation of medium and high cloud was prevented by low cloud on a considerable number of occasions, and that, with broken low cloud (4 oktas or more), observations of medium and high cloud have been included but observations of their absence under these circumstances have been omitted. However the purpose of the present investigation was to establish if any pronounced relationship between the jet stream and upper cloud existed, and statistical

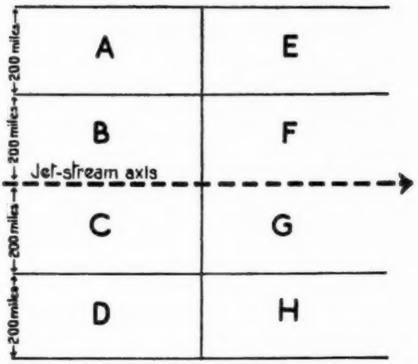


FIG. 1—SECTORS USED FOR STUDY OF CLOUD DISTRIBUTION IN RELATION TO THE JET STREAM

corrections for the unrepresentative nature of some of the data have not yet been attempted.

The most noteworthy features of Tables I and II are the following:—

(*a*) Amounts of cirrus of 4 oktas or more are considerably more frequent to the right of the axis of the jet stream (sectors C, D, G and H) than to the left (sectors A, B, E and F). This is brought out in Table III which gives the percentage frequency of cloud 4 oktas or more to the left and right of the jet-stream axis. The relationship was slightly more pronounced with the stronger jets.

There is little difference between the sectors longitudinally along the jet in respect of high-cloud amount, but this is not to be interpreted

TABLE I—FREQUENCY OF MEDIUM AND HIGH CLOUD AMOUNTS IN VARIOUS SECTORS OF THE JET STREAM

Percentage of the total number of observations of medium or high cloud together with observations of no medium or high cloud and low cloud less than 4 oktas. Maximum speed in jet stream >70 kt.

Sector	Cloud amount (oktas)					Total No. of obs.	Sector	Cloud amount (oktas)					Total No. of obs.
	0	1-3	4	5-7	8			0	1-3	4	5-7	8	
	percentage frequency							*percentage frequency*					
MEDIUM CLOUD													
A	38	23	17	16	6	154	E	34	16	15	20	16	335
B	50	21	12	11	5	256	F	34	21	12	18	15	574
C	30	25	15	21	10	334	G	36	16	12	20	16	764
D	31	17	14	24	14	177	H	34	12	13	23	17	641
HIGH CLOUD													
A	37	44	12	6	1	95	E	37	46	10	5	2	205
B	45	30	16	7	2	201	F	58	27	5	8	1	308
C	22	49	19	8	2	192	G	31	35	18	12	4	458
D	29	32	23	11	5	104	H	29	36	17	17	1	369

TABLE II—FREQUENCY OF MEDIUM AND HIGH CLOUD TYPES IN VARIOUS SECTORS OF THE JET STREAM

Percentage of the total number of observations of medium or high cloud together with observations of no medium or high cloud and low cloud less than 4 oktas. Maximum speed in jet stream >70 kt.

Sector	Cloud type* 0	1	2	3	4	5	6	7	8	9	Total No. of obs.	Sector	Cloud type* 0	1	2	3	4	5	6	7	8	9	Total No. of obs.
	percentage frequency												*percentage frequency*										
MEDIUM CLOUD																							
A	38	2	6	7	9	2	26	9	1	1	154	E	34	5	14	7	7	1	19	13	1	0	335
B	50	2	5	10	7	2	14	9	0	<1	256	F	34	4	12	9	7	1	20	12	1	<1	574
C	30	4	6	13	11	2	8	22	3	1	334	G	36	5	12	9	10	2	10	15	1	<1	764
D	31	5	12	9	9	2	0	21	7	3	177	H	34	6	12	11	11	2	4	19	1	1	641
HIGH CLOUD																							
A	37	9	15	23	5	2	2	2	0	4	95	E	37	11	15	22	1	3	4	2	3	2	205
B	45	9	9	15	3	3	9	1	4	2	201	F	58	5	5	15	2	4	5	2	3	1	308
C	22	21	17	8	2	5	10	4	6	5	192	G	31	15	18	6	2	7	6	4	4	5	458
D	29	15	22	2	5	8	6	7	4	3	104	H	29	19	19	3	3	6	8	2	5	·5	369

*International code figures as used in 1949 (see " Handbook of weather messages, codes and specifications ", London, 1949, Part II, pp. 20 and 21).

as indicating no difference between the entrance and exit to the jet stream —probably only a few of the observations are really close to either the exit or entrance; the observations are mainly typical of the central region.

The more or less corresponding increase of cirrus amounts from sector A to D and from E to H lends support to the reality of the distribution of high cloud. Cirrus was not reported from sector D in the jet streams exceeding 120 kt.

(*b*) Medium-cloud amounts appear to be less in sectors A and B, i.e. the left entrance to the jet, but the amounts in other sectors show little variation.

(*c*) The statistics of cirrus types show, as would be expected, a dominance of cirrus type 3 (anvil cirrus) to the left of the jet stream and a relative abundance of the frontal and layer types of cirrus to the right. Again the relationship was slightly better developed with the stronger jets. In order to bring out the difference between the character of the cirrus cloud Table IV gives the frequencies of the layer types of cirrus (types 4–8), and the frequency of no cirrus and anvil cirrus (type 3) added together for the various sectors.

(*d*) The statistics of medium-cloud types show a remarkable predominance of type 6 (altocumulus formed by the spreading out of cumulus) to the left of the jet stream. Altostratus, frontal type of altocumulus and altocumulus castellatus are more common to the right of the jet.

TABLE III—PERCENTAGE FREQUENCY OF MEDIUM AND HIGH CLOUD 4 OKTAS OR MORE TO THE LEFT AND RIGHT OF THE JET STREAM

	To the left of jet stream (sectors A, B, E and F)		To the right of jet stream (sectors C, D, G and H)	
	All jet streams >70 kt.	Strong jet streams >120 kt.	All jet streams >70 kt.	Strong jet streams >120 kt.
	percentage frequency			
MEDIUM CLOUD	41	37	50	60
HIGH CLOUD	19	18	34	39

TABLE IV—PERCENTAGE FREQUENCY OF LAYER TYPE CIRRUS AND NO CIRRUS OR ANVIL CIRRUS IN VARIOUS SECTORS

Sector	All jet streams >70 kt.	Strong jet streams >120 kt.	Sector	All jet streams >70 kt.	Strong jet streams >120 kt.
	percentage frequency			*percentage frequency*	
LAYER TYPE CIRRUS					
A	12	15	E	14	14
B	20	18	F	16	15
C	27	35	G	24	24
D	29	44	H	24	36
NO CIRRUS OR ANVIL CIRRUS					
A	60	62	E	59	70
B	51	67	F	72	79
C	30	32	G	37	37
D	31	0	H	32	19

Notes on individual jet streams.—For several jet streams fairly complete sets of observations of cirrus cloud were available. It was noteworthy that on most occasions when a clear limit to an area of cirrus could be defined, this limit lay close to the axis of the jet stream. These were mainly the cases in which the jet stream was associated with an active front. On the other hand there were a number of jet streams through surface ridges of high pressure in which upper cloud amounts were small or zero in all sectors for which observations were available.

Conclusions.—There is statistical evidence that cirrus cloud is considerably more frequent and extensive to the right of the axis of the jet stream than to the left. The frontal and layer types of cirrus and medium clouds are more common to the right of the jet stream; anvil cirrus and altocumulus from the spreading out of cumulus are more common to the left. There is some suggestion from the study of individual cases that when a well defined boundary to the frontal cirrus occurs the axis of the jet stream is found close to this boundary, but the evidence is insufficient to establish this with certainty. There is little evidence for any variation of the cloud distribution along the length of the jet stream except for the relatively low frequency of medium cloud in the left entrance. However, the mode of analysis was not suitable to bring out features which affect only small areas near the exit or entrance of the jet stream.

AN AUTOMATIC SELECTING DEVICE FOR "SFERIC" OBSERVATIONS

By A. L. MAIDENS, B.Sc.

A full account of the "sferic" system for the location of thunderstorms, and of the operational methods employed, was given by C. V. Ockenden in the *Meteorological Magazine* for April 1947. In brief the system depends on the measurement at four remotely separated stations of the directional bearing of the atmospheric produced by a single lightning flash.

It will be appreciated that as practically all lightning flashes within a radius of at least 1,500 miles from the British Isles produce measurable signals on the apparatus, some degree of selection must usually be exercised. When the

activity is considerable it is impracticable to locate all lightning flashes occurring within this area. It suffices to obtain sufficient observations to identify each active storm centre.

For this purpose a random selection of flashes is required to be observed, no preference being given either to direction or to signal strength, providing, of course, this is sufficient to give a readable signal.

In practice it has been found that visual selection by an observer at the control station may not necessarily be truly random, and that there can be a tendency both to over-select in particular directions, and to ignore weaker signals in preference to the stronger ones. Thus the more active or nearer storms may be represented by an excessive number of fixes, while weaker or more distant activity remains unrecorded, or supported only by a minimum of evidence.

To overcome this limitation in the " sferic " system it was recently decided to proceed with the design of an automatic selecting device, the requirement for which was that it would be actuated by any reasonable strength of signal. It was furthermore necessary for the apparatus to emit an audible warning note simultaneously with the arrival of the incoming signal, and for there to be a time delay between the lightning flashes so selected.

Mr. N. Lewis of the cathode-ray direction-finding unit at Dunstable has now designed and constructed equipment which meets all these requirements and which has given entire satisfaction in operation. It was found by trial that a minimum time-delay of about seven seconds allowed each set of bearings to be read, transmitted and recorded at Dunstable without undue haste.

In order that the warning signal could be transmitted over the private telephone lines of the " sferic " network, an audible note of a pitch in the range 800–1,000 c./sec. was chosen. The sharp "pip" emitted by the warning apparatus was found to stimulate the response of the observers, and obviated the possibility of reading an incorrect signal, when flashes occurred in quick succession.

The visual indication of lightning flashes given by the cathode-ray tube of the sferic equipment remains unaffected by this additional apparatus, and such flashes remain observable even during the time-delay period of the selecting device. Thus it is possible, should the controlling station so desire, to " call " orally any extra observations which may be of particular interest.

A further advantage of which the selecting device is capable is that its signal could be used to operate a wireless transmitter in lieu of a morse key. By this means a " sferic " network could be controlled in a remote area without the need either for installing an expensive land-line communications system, or for resorting to radio-telephony with its inherent limitations of range. The bearings of the flashes selected by the " pipper " could be transmitted to the controlling station by any available means of communication.

Two sets of the selecting equipment have now been built at an estimated cost each of about £5 for components. One is in routine operation at the new Meteorological Office " sferic " station at Hemsby, near Yarmouth, which has now taken over from Dunstable the task of selecting the lightning flashes to be observed. The second is retained at Dunstable, and is used for monitoring the work of the network and for general investigation purposes.

THE PROLONGED UNPLEASANT WEATHER OF 1950–51

By J. GLASSPOOLE, Ph.D.

The winter of 1950–51 was unusually cold and wet. It followed a wet autumn and wet summer, while the spring of 1951 was also very wet with temperatures below the average, so that the run of unpleasant weather was unusually prolonged. Generally wet weather set in with July 1950, and the monthly values of temperature, rainfall and sunshine from July 1950 to May 1951 are therefore given below.

TABLE I—MONTHLY VALUES OF TEMPERATURE, RAINFALL AND SUNSHINE FROM JULY 1950 TO MAY 1951

	ENGLAND AND WALES					SCOTLAND					NORTHERN IRELAND			
	Temperature		Rainfall		Sunshine	Temperature		Rainfall		Sunshine	Temperature	Rainfall		Sunshine
	Mean at M.S.L.	Difference from average	Amount	Percentage of average	Percentage of average	Mean at M.S.L.	Difference from average	Amount	Percentage of average	Percentage of average	Difference from average	Amount	Percentage of average	Percentage of average
	°F.	°F.	in.	%	%	°F.	°F.	in.	%	%	°F.	in.	%	%
1950														
July	61·5	+0·4	3·9	137	100	58·4	+0·6	5·0	133	113	+0·1	6·5	191	92
Aug.	61·2	+0·3	5·1	147	99	58·1	+1·0	5·2	115	116	−0·2	5·6	135	95
Sept.	56·5	−0·5	5·0	196	79	52·6	−0·5	10·3	257	87	−0·5	7·7	256	82
Oct.	50·9	0·0	1·7	44	100	48·2	+0·2	4·8	98	98	+0·3	3·9	108	98
Nov.	43·7	−0·4	6·0	172	95	40·5	−1·7	5·5	103	117	−2·2	3·0	79	122
Dec.	35·9	−5·6	3·0	76	102	34·4	−5·5	3·5	60	120	−5·8	4·0	97	88
1951														
Jan.	40·0	−0·5	3·8	127	93	37·5	−1·9	6·3	130	104	−1·7	3·7	112	121
Feb.	39·7	−0·9	4·8	186	96	37·5	−2·1	4·3	103	96	−3·3	3·4	113	120
Mar.	40·8	−2·1	4·7	174	83	38·3	−2·7	3·9	95	82	−2·0	2·9	97	87
April	45·3	−1·3	2·9	135	125	41·8	−2·4	4·5	150	114	−1·6	1·8	71	111
May	51·0	−2·2	3·2	140	88	48·1	−1·5	1·9	63	124	−2·1	1·9	72	114

Temperature.—The mean temperature over Great Britain and Northern Ireland was below the average in September 1950 and again for seven consecutive months from November 1950 to May 1951. This long spell of cold months was trying, not only because of the associated wet weather, but also because it followed a long run of relatively warm months. Over England and Wales the 15 consecutive months June 1949 to August 1950 all had above the average temperature. Indeed over both England and Wales, and Scotland during the 24 months ending August 1950 the temperature of every month but two had exceeded the average.

December 1950 stands out as the coldest December over the British Isles as a whole since 1890, and in Scotland probably since 1886. During the present century there have been only six colder months over England and Wales, four Januaries and two Februaries, and over Scotland only three Januaries and one February. In addition to the outstandingly cold December, the following three months were each colder than usual, giving a long spell of wintry weather. The spring months continued to be colder than usual, but temperatures rose in places in both April and May to well over 60°F.

Table II gives a comparison of the temperatures recorded from September 1950 to May 1951 with those of other similar cold periods, the data being arranged in seasons.

This shows that the cold weather of 1950–51 was by no means unprecedented, although it persisted for three seasons.

TABLE II—DIFFERENCE FROM THE AVERAGE MEAN TEMPERATURE OVER ENGLAND AND WALES DURING RECENT COLD PERIODS

	Autumn September–November	Winter December–February	Spring March–May
		degrees Fahrenheit	
1950–51	−0·4	−2·2	−2·0
1946–47	+1·4	−5·3	+0·2
1940–41	0·0	−2·9	−2·3
1923–24	−2·2	−0·4	−1·5
1916–17	+0·4	−4·6	−2·2

Rainfall.—Over England and Wales the rainfall exceeded the average in nine out of the eleven months, over Scotland in seven months and over Northern Ireland in six months. While the run of consecutive wet months is by no means unprecedented, some of the months were outstandingly wet. September 1950 was the wettest September over Great Britain and Northern Ireland since 1869 except for that of 1918. February 1951 was the wettest February on record over part of south-east England, including the London area. The total rainfall of July to September 1950 over Great Britain exceeded that of any similar period since 1869, due mainly to the large amounts recorded in Scotland. The rainfall of January to March 1951 was more remarkable over England and Wales, where it exceeded that of any similar period since 1869 apart from that of 1937.

Sunshine.—The general values for sunshine show that whereas over England and Wales the weather persisted generally duller than usual until the welcome sunshine of April, over Scotland the dull weather prevailed only in September and October 1950 and February and March 1951. Over Northern Ireland the main dull period was restricted to the period July–October 1950.

The weather of 1950–51 was unusual therefore in that the run of wet months was long sustained, while at the same time cold weather also prevailed. The wet September of 1950 over Scotland, the wet February of 1951 over England and Wales, and the widespread cold December of 1950 were outstanding.

WIND RECORDING INSTRUMENTS FOR USE NEAR THE SITE OF THE PROPOSED SUSPENSION BRIDGE OVER THE SEVERN

By G. E. W. HARTLEY, M.A.

In April 1949 the Meteorological Office was asked by the Ministry of Transport to provide instruments for recording the speed, horizontal direction and vertical inclination of the wind at various points across the span of an existing bridge over the Severn at Sharpness, which is not far from the site of the proposed new bridge near Chepstow.

The object of these measurements was to provide data for making wind-tunnel tests on a model of the bridge.* Experience on other suspension bridges has shown that a sustained wind inclined to the horizontal may set up movements in the bridge which may build up until failure occurs; and it was hoped that these measurements would show whether such inclined winds do occur and persist.

The scheme first suggested was to have two pressure-tube anemographs recording in small huts on the bridge, and four special wind vanes which would

*FRAZER, R. A.; The Severn Bridge aerodynamic research. *Nature, London*, **163**, 1949, p. 7.

FIG. 1—BI-DIRECTIONAL WIND VANE

To face p. 285]

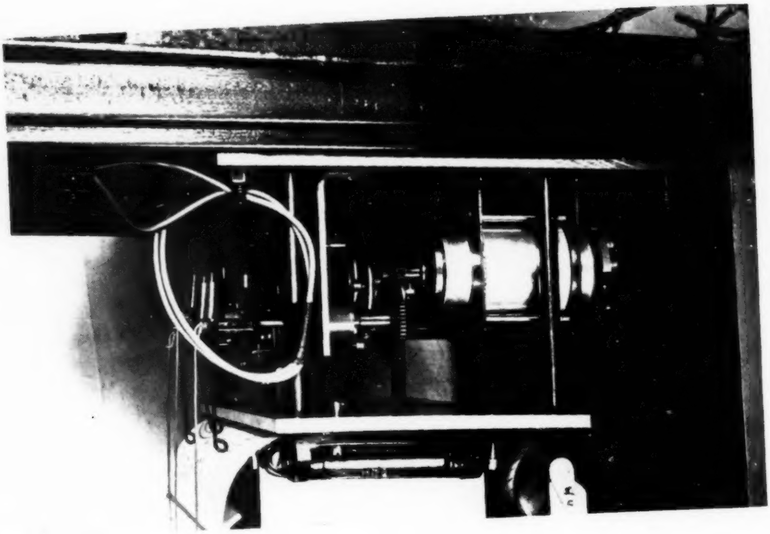


FIG. 4—MECHANISM OF WIND-DIRECTION RECORDER

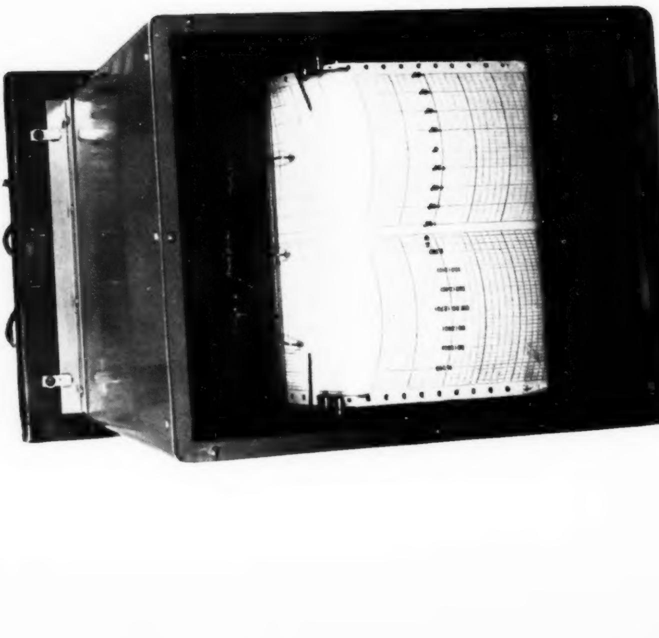


FIG. 3—WIND DIRECTION RECORDER

record inclination of the wind on a standard daily clock drum carried in a housing forming part of the vane; this scheme was subsequently abandoned because of the difficulty of reconciling accessibility (for chart changing) with good exposure; and it was decided to use the magslip self-synchronous a.c. system of remote transmission for both wind directions, and to use recording cup-generator anemometers for speed. There would be four positions across the span of the Sharpness Bridge, at each of which would be a bi-directional transmitting wind vane, and a cup-generator anemometer, all connected through wiring to recorders grouped together in a hut at one end of the bridge. If the necessary electric power was not available at the site, this would be generated by the steam power used to operate the swing span of the bridge when available, and by stand-by petrol electric generators when the steam power was not available.

The bi-directional vane as first designed is shown in Fig. 1 (facing p. 284) and also diagrammatically in Fig. 2. A wind vane A is pivoted on a horizontal

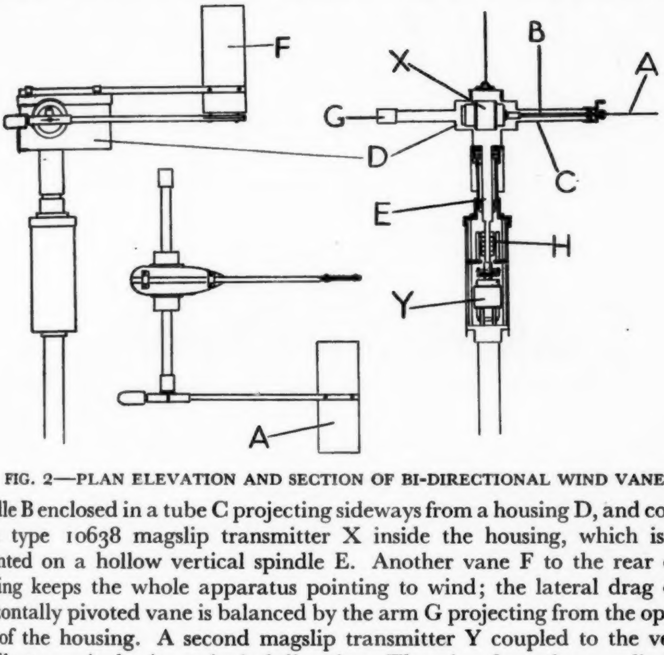


FIG. 2—PLAN ELEVATION AND SECTION OF BI-DIRECTIONAL WIND VANE

spindle B enclosed in a tube C projecting sideways from a housing D, and coupled to a type 10638 magslip transmitter X inside the housing, which is itself mounted on a hollow vertical spindle E. Another vane F to the rear of the housing keeps the whole apparatus pointing to wind; the lateral drag of the horizontally pivoted vane is balanced by the arm G projecting from the opposite side of the housing. A second magslip transmitter Y coupled to the vertical spindle transmits horizontal wind direction. The wires from the magslip X are brought down inside the hollow spindle to slip rings and brushes H. The whole transmitting system is enclosed in a weather-proof housing.

The wind-direction recorder is shown in Figs. 3 and 4 (opposite) and consists of a board on which are mounted the two direction receiving magslips. The horizontal-direction magslip carries on its spindle two cams; roller-bearing cam followers engaging with these cams carry on their axes the stirrups which hold the recording pens. The upper cam is so shaped that as it turns through 360° the pen moves from one side of the chart to the other and back again. The

chart is marked with N. on the left side, S. on the right side, and both E. and W. at the centre; and the pen is at the same position on the chart for east as for west. The lower cam operates a second pen close to the right side of the chart, and is so shaped that the pen is in one of two positions, one position indicating that the other pen is in the west quadrant, the other in the east quadrant. The scale is 3 in. to 180°. When the wind direction is changing about north or south, there may be some doubt whether the record is on the east or west side; but for this particular investigation a time scale of 12 in./hr. is used which helps to lessen this difficulty; and horizontal direction is not so important as inclination and horizontal speed. The vertical-inclination magslip drives its pen spindle through reduction gearing, so that 4 in. on the chart represents 160° of vane movement, i.e. ±80° to the horizontal. The strip chart mechanism is mounted on a plate carried on pillars in front of the two magslips. Fig. 4 shows the cams and gears and part of the chart mechanism.

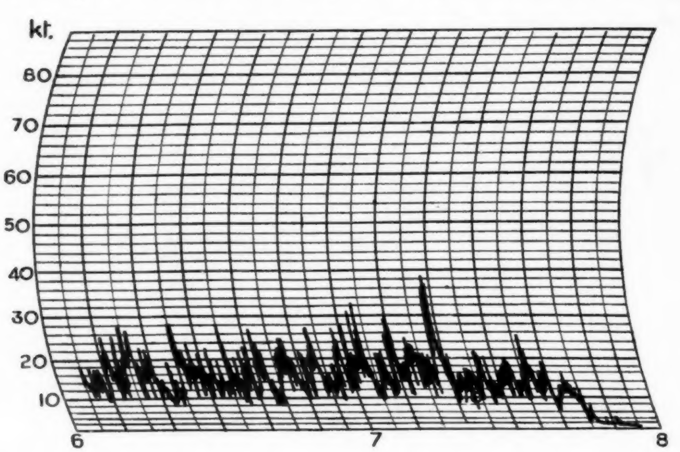


FIG. 5—WIND SPEED RECORD

The pens consist of small diameter tubes with a fine writing nozzle at one end, the other end dipping in an ink reservoir. Ink flows by capillary action, not by siphon. Specimen charts for wind speed and direction are shown in Figs. 5 and 6. In Fig. 6 the wind direction is shown by the upper trace and the vertical inclination by the lower trace.

Unfortunately owing to delay in delivery of the direction-recording chart mechanisms the Sharpness installation is not, at the time of writing, yet in operation; but one complete instrument has been in use at Beachley since January 1951; it is mounted on a 100-ft. steel mast near to an existing pressure-tube anemograph. The results are being examined by the Severn Bridge engineers, but this instrument is being used mainly to find out what defects exist and what modifications are necessary.

As a result of this preliminary trial the wind-direction recording gear is being modified for the Sharpness instruments. The engineers are not interested in changes of vertical inclination lasting only a few seconds; but they are interested when such changes persist over several minutes. It is therefore desirable for

the inclination vane not to respond to momentary changes of inclination, but to record any change which persists for, say, more than half a minute. The method to be used was suggested by Dr. Frith; the inclination vane is constructed as in Fig. 7; a ring of polythene tubing is carried on horizontal and vertical spokes, the horizontal spokes carrying the fin and balance weight. At the top of the ring the bore is constricted by a fitting having an adjustable opening. The ring is about one third filled with mercury, the whole assembly being accurately balanced before the mercury is introduced. When the vane is subjected to a change of wind inclination, the fin attempts to turn the vane to the appropriate direction; but the weight of mercury in the lower part of the ring resists this movement as the mercury can only move round in the ring as fast as it can push the air through the constriction. If however the inclination of the wind persists long enough, the mercury will eventually displace enough air to enable it to take up a new position, and the vane will now take an inclined position until a further persistent change of wind inclination moves it again. Thus the response of the vane may be varied by adjusting the size of the constriction.

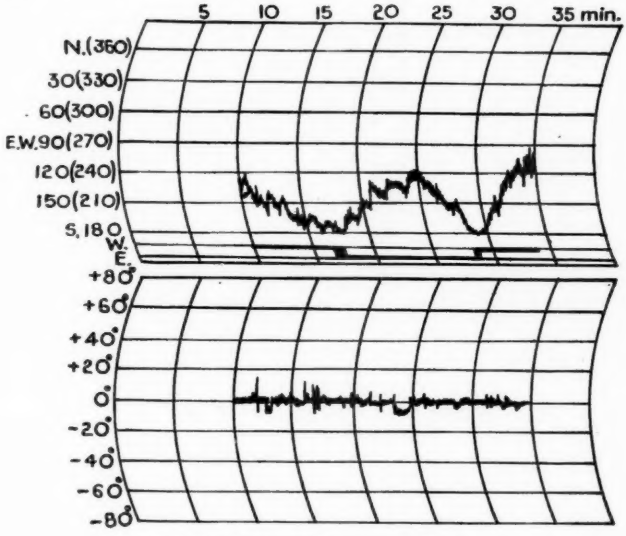


FIG. 6—WIND-DIRECTION RECORD

In the vane at present in use the horizontal-direction vane has been found not to exert enough leverage to turn at low wind speeds, and it is being enlarged and lengthened.

Another defect revealed by trial has been a zero change of the recording pen, due to the stirrup on which the pen is mounted slipping on its axis. Means of checking whether this has occurred are being provided by fitting to the spindle of the receiving magslip an indicator disc fixed relative to the spindle; a mark on this disc is set to come opposite to a fixed mark when the vane inclination is zero, and the chart stirrup and pen can be set to read zero when the two marks coincide; the pen can be adjusted if it does not read zero when checked in this way.

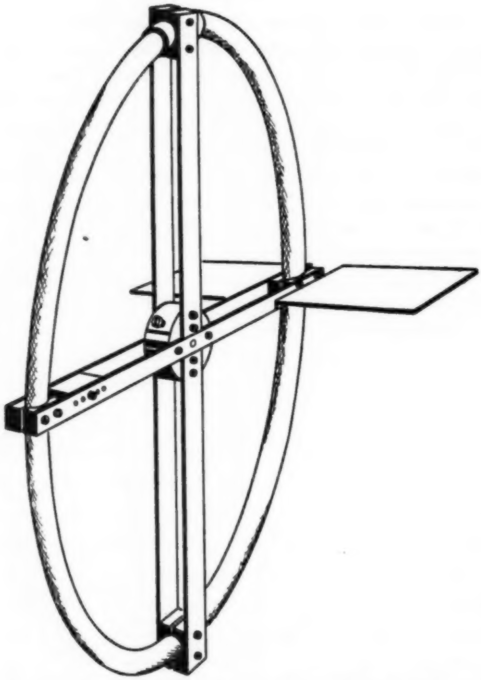


FIG. 7—INCLINATION VANE WITH RING DAMPER

A further modification is to alter the gear ratio of the inclination receiving magslip to give a larger inclination scale which is now to be $\pm 40°$ instead of $\pm 80°$, and to fit stops to the inclination vane to limit its movement to $\pm 40°$.

KATABATIC WIND AT DRIFFIELD

By R. H. ELDRIDGE, B.Sc.

The geographical factor leading to the Driffield katabatic wind is the presence of the Yorkshire Wolds. This low range of hills is shown in Fig. 1, the distance of the top of the ridge from the airfield varying from 11 miles in the west to 6–8 miles in the north. The highest parts of the ridge lie west to west-north-west from the airfield (itself one mile west-south-west of Driffield) and are about 700 ft. above the airfield level. The slope is generally fairly uniform. There are two very different types of soil in the area, and the line between the two (shown on the map) follows roughly the 150-ft. contour. South and east of the line the soil is glacial drift, mainly fairly heavy, but with patches of lighter drift; north and west of the line the soil is " wold ", with chalk as the underlying rock. This soil varies in texture but is not heavy. The chalk drains naturally and there is no need for the ditches and drain pipes which are so very necessary on the glacial drift from the wolds to the sea,

The eye observations used in this paper were taken from the balcony of the meteorological office on the headquarters building, R.A.F. Driffield, 25 ft.

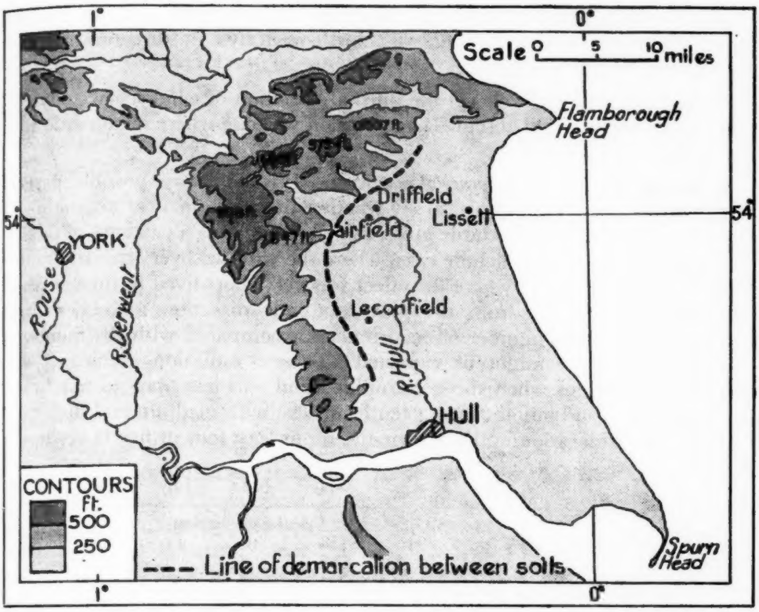


FIG. I—YORKSHIRE WOLDS, EAST RIDING OF YORKSHIRE

above the ground. Temperatures were taken from the screen on the ground near by. Wind direction and wind speed were taken from a vane and cup anemometer on the headquarters building at a height of about 45 ft. above the ground. Driffield airfield is well exposed to any flow of air from the north-west, only isolated clumps of trees offering any hindrance. Between the meteorological office and the airfield, buildings, varying in size from small huts to hangars, extend in the north-west quadrant from the meteorological office for a distance varying between 300 and 600 yd.

The records of the six months from March to August 1943, inclusive, have been thoroughly searched for occasions of katabatic winds. The following data have been extracted from the records:—

(i) Time of start of wind
(ii) Duration of wind
(iii) Strength of wind
(iv) Component of geostrophic wind in direction of " pure " wind
(v) Rate of fall of temperature before onset of wind
(vi) Indication of lapse rate of temperature in the vertical.

Some unusual variations in surface temperature, humidity, visibility and local cloud effects have also been noted.

The effect of the wind may be considered in two main groups:—

(*a*) A " pure " wind, where the pressure gradient taken from a chart of sea-level pressure is either non-existent or opposed to the natural direction of the wind. This wind is from WNW., Beaufort force 1 or 2. At only one hour during the six months dealt with in this paper was force 3 recorded, this being just 8 m.p.h.

(*b*) A wind, similar in speed to that expected from the pressure gradient, but considerably different (i.e. west-north-westerly) in direction. This is generally of force 1 or 2.

On one occasion (March 14) the diurnal variation of wind speed and direction was almost entirely absent. The occasion was one where a katabatic wind was probable.

Analysis of data.—*Frequency of occurrence.*—It is not always possible, particularly in a retrospective analysis, to say whether the wind on a certain night was or was not katabatic. The table given therefore contains a category of possible katabatic effects. These include cases where the wind was very similar at other Yorkshire stations, some where the effect was very short-lived in time or where the wind was too far from the pure katabatic direction to be considered as such a wind. The number of occurrencies is compared with the number of occasions when one might be expected. These " radiation evenings " were defined as occasions when the geostrophic wind was less than 30 m.p.h. and when the low cloud amount was 4 tenths or less, with medium and high cloud taken into consideration in the assessment, for at least four or five hours around sunset.

	Mar.	Apr.	May	June	July	Aug.	Total
			number of occasions				
Radiation evenings	17	10	18	12	14	11	82
Katabatic winds	6	3	6	7	8	5	35
Possible katabatic wind	4	4	4	2	2	2	18

11 of the 35 occasions were pure effects, but this small proportion is largely because of the generally prevailing south-westerly winds.

Time of onset.—The time of start of the wind, expressed as hours after sunset, is shown below.

	Time from sunset to start of wind (hr.) 1	2	3	4	5	6	Mean time
			number of occasions				hr.
Pure wind	...	2	5	2	1	1	3·5
Aided wind	3	5	9	3	3	1	3·0
Total	3	7	14	5	4	2	3·1

As the winds were generally noted only at the normal hourly observations these average figures are probably each too large by about ½ hr. Where the wind showed as a marked change in direction, as was frequently the case, this was generally complete between two hourly observations. There was rarely a gradual change with an increasing component from a west-north-west direction as would be expected.

Duration.—Of the eleven occasions of pure katabatic wind, seven lasted till dawn or beyond (by one or two hours), in three the wind stopped one or two hours before dawn, and in one, after only one hour; this last occasion (March 14) is referred to below. Of the 24 aided occasions 18 lasted till dawn or beyond, though on some of these occasions the wind was continuous with the normal day-time surface wind.

Vertical and horizontal structure.—Very little direct information could be obtained on the vertical structure. The only occasions when a pilot balloon would give useful information would be when the normal pressure gradient was almost

opposite to the katabatic direction, and such occasions were few. Only one ascent was made in a katabatic wind and the balloon veered so rapidly that no theodolite readings could be obtained. But it seemed that little of the effect extended above 200–300 ft. Indirect evidence from low-stratus formation on March 14, referred to later, suggests that on this occasion the wind was certainly effective to 200–300 ft. Katabatic winds have been experienced occasionally at Lissett and Leconfield, but of force 1 only.

Rate of fall of temperature.—The rate of fall of the dry-bulb screen temperature at Driffield for the three hours before the start of the wind was obtained for each occasion, with the following results.

	Rate of fall of temperature (°F./hr.)			
	0·0–0·9	1·0–1·9	2·0–2·9	3·0–3·9
	number of occasions			
Pure	1	3	3	4
Aided	1	7	12	4
Total	2	10	15	8

Geostrophic wind.—The component of the geostrophic wind from WNW. was obtained from three-hourly charts. In some cases of light gradient the Spurn-Head surface wind was taken as being a representative sea-surface wind, and this enabled significant errors to be avoided. On only one occasion of pure katabatic wind was the component opposing the wind greater than 10 m.p.h. (18 m.p.h.). Aided winds occurred with all values of the components up to 20 m.p.h., and one of 25 m.p.h.

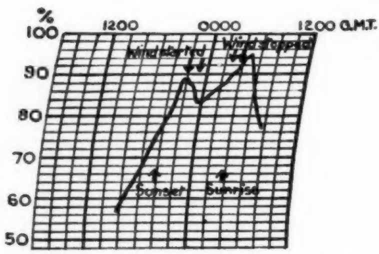
Vertical temperature distribution.—The temperature distribution in the vertical could obviously not be obtained very accurately. It was, however, felt worth while to attempt some estimation. The figures below give the change in temperature from the surface to 2,000 ft. at the time of start of the wind at Driffield. These have been derived from 950 mb. temperatures interpolated from all available radio-sonde and aircraft ascents.

	Temperature difference (°F.) at the start of the wind (2,000 ft. minus surface)							
	−6, −5	−4, −3	−2, −1	0,1	2,3	4,5	6,7	8,9
	number of occasions							
Pure katabatic	←1 (indeterminate)→			1	2	2	4	1
Aided katabatic	1	5	2	6	7	2	...	1

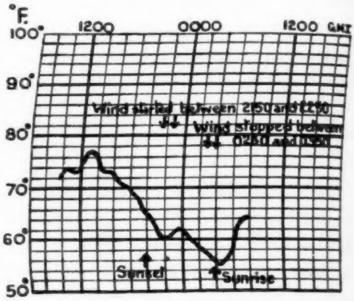
For some of the occasions interpolations could be made from actual 1,000-ft. temperatures obtained from soundings though naturally less reliance could be placed upon these figures due to local influences. Thirteen of these values were obtained and varied from a lapse of 1°F. to an inversion of 14°F. at the start of the wind.

Effects of wind.—*Surface temperature and humidity.*—On some occasions inspection of the thermograph traces showed either a rise in dry-bulb temperature or a decrease in the rate of fall of temperature shortly after the start of the wind. On one or two occasions there was a fall in the humidity shown on the hygrograph trace. Newnham[1] noticed that this occurred with the katabatic wind at Benson, and pointed out that the temperature rise was due to the stirring up of the lower layers which were previously stably stratified. With the reservation already noted about upper air temperatures in this paper it may be stated that the occasions (about ten) which showed this temperature effect

all had a marked increase of temperature to 1,000 ft. The decrease in relative humidity at screen level is of course not a necessary result of this mixing. The two effects are well shown on the traces for July 28, reproduced below. At 2100 and 2200 G.M.T. there was no wind but by 2300 the katabatic wind was blowing from WNW., force 2, and continued between force 1 and 3 for five hours. On other occasions the effect appeared as a check to the cooling, displacing the trace one, two or three hours. During this period of six months there were no cases where the wind brought in distinctly cooler air, but it should be pointed out that certain days of exceptional cooling in October and November 1948 appear to have been connected with the wind.



RELATIVE HUMIDITY FOR JULY 28–29, 1943



DRY-BULB TEMPERATURE FOR JULY 28–29, 1943

Visibility.—It is considered that the wind helps to give better visibility at Driffield than at some other airfields in Yorkshire. This is attributed by some to actual deflection of smoke-laden air from the industrial areas to the south-west and this probably does play some part. But it is also very probable that the temperature effect described above is important in delaying cooling and consequent condensation.

Low cloud.—On March 14 the katabatic wind, following a day-time sea breeze, appeared to hasten the formation of low stratus at 200–300 ft.

Consideration of results.—The data available are very inadequate for anything approaching a full analysis from which an understanding of the mechanism could be obtained. The geostrophic wind is the only guide to the wind shear in the lowest layers as is the interpolated 1,000 or 2,000-ft. temperature, together with that at the surface, the only available guide to the thermal structure. Observations at Driffield necessarily show the effect of the wind some time after it has started and away from the actual hillside above which the energy of the wind is generated. The analysis has also excluded certain occasions when the wind was west-south-westerly or north-west to north-north-westerly which might well have been katabatic, and one or two occasions where the wind blew for a very short time only and had been preceded by a small rate of fall of temperature (of the order of 1°F./hr.). These may well have been significant and are included in the " possible " category.

Early cessation of the wind may well be accounted for in some cases by the loss of energy involved in stirring the stably stratified air. Cornford[2] and Heywood[3] both comment that the katabatic winds they observed appeared to cease by the time a large inversion had been set up.

No hard forecasting rule can be produced from the analysis, but with a geostrophic gradient of 10 m.p.h. or less (whatever the direction), less than a quarter of the sky covered for three or four hours after sunset and a high day-maximum temperature, a katabatic wind is almost certain. There is a good chance of it with gradients up to 20 m.p.h. It may be expected to start about 2–3 hr. after sunset and last till about dawn.

Acknowledgement.—I am indebted to the County Agricultural Officer, East Riding of Yorkshire, for the information on soils.

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1. NEWNHAM, E. V.; Notes on examples of katabatic wind in the valley of the upper Thames at the aerological observatory of the Meteorological Office at Benson, Oxon. *Prof. Notes met. Off., London,* **1,** No. 2, 1918.

2. CORNFORD, C. E.; Katabatic winds and the prevention of frost damage. *Quart. J. R. met. Soc., London,* **64,** 1938, p. 553.

3. HEYWOOD, G. S. P.; Katabatic winds in a valley. *Quart. J. R. met. Soc., London,* **59,** 1933, p. 47.

OFFICIAL PUBLICATION

The following publication will be issued shortly:—

Annual Report of the Director of the Meteorological Office presented by the Meteorological Committee to the Secretary of State for Air for the year April 1, 1950, to March 31, 1951.

The Report describes the work of the State Meteorological Service. The work covers the meteorological needs of the Royal Air Force, civil aviation, other government departments and public utility corporations, the general public, agriculture, the Merchant Navy and industrial concerns. Services to these bodies have been improved and extended during the year. New meteorological offices have been opened to meet the needs of the expanding R.A.F. For civil aviation, new meteorological broadcasts by radio-telephone have been introduced to conform with changed practices of airline operators. For agriculture, a potato-blight warning system was tried out and proved very successful, and warnings of frost and snow were extended.

The amount of flying at great heights (above 40,000 ft.) is increasing rapidly, and in consequence much investigation of turbulence and on forecasting winds at these levels has been done. Among the many other subjects of research mentioned in the Report are the visibility of airfields from the air in poor meteorological conditions, methods of forecasting for comparatively long periods, the physical conditions in clouds, especially in relation to gust structure and the icing of aircraft. In these last investigations considerable use has been made of radar. Development work has also been done on a number of new instruments, in particular the radar theodolite, for the measurement of upper winds.

The geophysical observatories at Kew, Lerwick and Eskdalemuir have continued to make observations and automatic records of meteorological elements, terrestrial magnetism, solar radiation, atmospheric electricity and seismic movements.

The responsibilities of the Meteorological Office overseas have been slightly reduced by the handing over to local governments of certain meteorological services in the Sudan, British Somaliland, Tripolitania and (to a limited extent) in Germany.

Senior members of the staff have attended meetings of the International Meteorological Organization and its successor, the World Meteorological Organization, and the International Civil Aviation Organization.

METEOROLOGICAL RESEARCH COMMITTEE

The sixteenth meeting of the Synoptic and Dynamical Sub-Committee of the Meteorological Research Committee was held on July 5, 1951. The main discussion was on an interesting essay by Mr. C. K. M. Douglas on the evolution of forecasting in the British Isles in the twentieth century[1]. Applications of recent lines of forecasting research were also considered in this connexion.

A detailed study by Mr. J. S. Sawyer[2] of the rainfall of two selected synoptic situations, a secondary depression and a warm front respectively, was discussed with interest. Other papers considered were a note on the usefulness of forecasts by Mr. A. F. Crossley[3], and a report on the accuracy of wind forecasts at altitudes of 30,000 ft. over Egypt by Mr. C. S. Durst[4].

The seventeenth meeting of the the Physical Sub-Committee of the Meteorological Research Committee was held on July 18, 1951.

Two papers by Mr. E. Knighting[5,6] were discussed. The first of these papers deals with the equation of turbulent diffusion in the atmosphere and sets out to give an account of the solution of this equation under the boundary conditions which are normally met with in meteorological problems. The second paper gives a solution of the power-law diffusion equation for the case in which the surface variation is of the form of a sine wave and offers some criticisms of the method hitherto used for the estimation of the index in the power law.

A paper by Mr. Bannon[7] dealing with an analysis of occasions of turbulence at high altitudes was also discussed.

A report[8] on the measurement of temperature fluctuations over very short periods of time and at high altitudes was presented by Mr. Grant.

[1]*Met. Res. Pap., London,* No. 654, 1951.
[2]*Met. Res. Pap., London,* No. 650, 1951.
[3]*Met. Res. Pap., London,* No. 653, 1951.
[4]*Met. Res. Pap., London,* No. 655, 1951.
[5]*Met. Res. Pap., London,* No. 598, 1951
[6]*Met. Res. Pap., London,* No. 609, 1951
[7]*Met. Res. Pap., London,* No. 660, 1951
[8]*Met. Res. Pap., London,* No. 658, 1951

LETTERS TO THE EDITOR

Effect of shelter hedges on mean temperature

Facing p. 344 of the December 1950 number of the *Meteorological Magazine* is a fine aerial photograph of Eskdalemuir Observatory, showing a substantial shelter belt of coniferous trees enclosing the area. It would be of considerable interest, especially from the agricultural point of view, to know just how shelter of this kind effects the local climate, for example, the daily range of temperature in summer.

Owing to its situation far from human interference, and to the high accuracy of the recording, the temperatures observed at Eskdalemuir are particularly suitable for indicating long-period fluctuations of the average. In order to examine the possible effect of the growth of the surrounding trees on the overall mean temperature, the following table compares those observed at Eskdalemuir with two very reliable records from the same region. For various reasons it is

thought that the values recorded at Blackfort Hill, Edinburgh, and those reduced by G. Manley for Lancashire, have not been affected by urban development during the period in question.

	20-year periods 1911–30	1921–40	1931–50
	degrees Fahrenheit		
Average mean temperature	44·30	44·70	45·00
Eskdalemuir minus Edinburgh	−2·55	−2·58	−2·66
Eskdalemuir minus Lancashire	−4·08	−3·92	−3·95
Average difference	−3·31	−3·25	−3·30

It would appear from these figures that the increasing height and density of the shelter belt at Eskdalemuir has had no significant effect on the overall mean temperature recorded there. Its effect on the daily range is a different matter.

The appreciable rise of mean temperature shown by the figures is interesting, but the period is too short to indicate how much of it is due to a temporary fluctuation. Manley's reductions for Lancashire, covering nearly two hundred years, suggests that the present century has been exceptional in this respect, earlier periods of rising average being of much shorter duration.

G. S. CALLENDAR

Percuil, Parsonage Road, Horsham, July 6, 1951

Forecasting ground frost

From investigations made at Münster, R. Faust* has proposed the formula

$$T + \frac{D}{2} < 79$$

for the forecasting of ground frost on radiation nights, where T and D are screen temperature and dew point respectively in degrees Fahrenheit at 1400 local time.

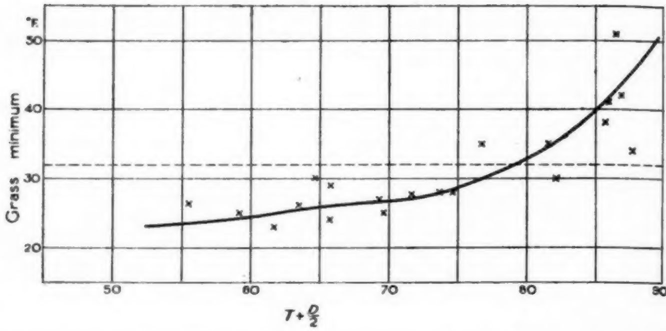
The formula has been derived for a lowland station (Münster) and should apply to an average station in fairly level country in the United Kingdom. It is also specified that cloud should be less than 2 tenths and wind speed less than Beaufort force 2 during the cooling period.

TABLE OF VALUES OF $T + D/2$ AND GRASS MINIMUM

Date	$T+\frac{D}{2}$	Grass minimum (next morning)	Date	$T+\frac{D}{2}$	Grass minimum (next morning)
	°F.	°F.		°F.	°F.
12.9.50	86·5	50·9	2.3.51	69·6	25·0
13.10.50	85·9	41·0	15.3.51	69·3	27·0
14.10.50	76·7	35·0	30.3.51	55·5	26·2
24.10.50	74·6	28·0	17.4.51	64·7	30·0
25.10.50	71·7	27·9	23.4.51	82·1	30·0
6.11.50	65·7	24·0	24.4.51	87·7	34·0
17.11.50	65·8	29·0	10.5.51	73·7	28·0
7.12.50	63·5	26·0	4.6.51	86·8	42·0
27.2.51	59·2	25·0	5.6.51	85·7	38·0
28.2.51	61·6	23·0	8.6.51	81·5	35·0

To test the formula all radiation nights at Hullavington were selected since September 1950 which fulfilled these requirements. The values of $T+D/2$ at 1400 G.M.T. and the grass minimum reading for the next morning are shown in the accompanying table and have been plotted against one another in the

*FAUST, R.; Ein Hilfsmittel zur Nachtfrostvorhersage. *Ann. Met., Hamburg*, 2, 1949, p. 105.



accompanying graph. The approximate curve of best fit is seen to cross the 32°F. line at about 79. The grouping of points about the line is not very close but no allowance has been made for the possible advection of different air between 1400 and the cooling period The results do appear to indicate that the formula can be used with some degree of confidence.

G. J. JEFFERSON

Hullavington, Chippenham, Wiltshire, June 14, 1951

NOTES AND NEWS

Climatological observations at Greenwich

With the transfer of the Royal Observatory from Greenwich to Herstmonceux Castle, now at an advanced stage, the long series of climatological observations on the Observatory site in Greenwich Park will shortly come to an end.

Climatological observations have been an official part of the work of the Royal Observatory since 1841 when its Meteorological Department was established and regular hourly observations began. Before that date a private record of temperature and rainfall was kept by one of the assistant astronomers, from 1815 onwards, and with the help of these data and of other series of observations from nearby stations it is possible to extend the temperature record back to 1811. The monthly totals of rainfall, adjusted to give a homogeneous series, 1815–1914, were published in *British Rainfall 1915*, pp. 36–7.

In general, however, the data cannot be regarded as homogeneous because of the progressive urbanization of the neighbourhood during the period covered. but this long record is of course of great interest and value for many purposes. The sunshine record, for example, shows the growing effect of London smoke, which eventually became one of the dominant disturbing factors in astronomical work leading to the decision to move the Observatory. The disturbing effects of urban conditions were not entirely on the dark side, however, as another factor was the interference from bright street lighting with long-exposure night-sky photography. As far as magnetic work is concerned, the disturbance resulting from the increasing use of electrical equipment led to the establishment of the alternative site for this work at Abinger in Surrey in 1924.

The complete cessation of climatological records at Greenwich would have been a matter of serious concern to many interested parties, and it is therefore pleasing to be able to report that a very satisfactory alternative arrangement

has been made. For various reasons there was no question of continuing the observations on a strictly comparable site in Greenwich Park, and a reconnaissance of the district showed that the next best site was undoubtedly in the grounds of the National Maritime Museum, a few hundred yards away. In fact, though any break in continuity due to a change from a long-established site is much to be regretted, it was expected that a site near the Museum would prove to have the advantage, over the comparatively elevated parkland site, of being more representative of the lower built-up ground which forms the major part of Greenwich and extends beyond the borough along the river.

When the Director of the National Maritime Museum was approached he showed great interest and readily consented to put before his Board of Trustees the proposal to set up within the grounds a small station to be equipped by the Meteorological Office and looked after by Museum Staff. The Board kindly granted their approval of the scheme and thus provided the prospect of continuing the basic observations on a good site for many years to come. The Director and his staff at once co-operated most enthusiastically in the early establishment of the station and observations began on May 1, 1951. All who are interested in climatology will share the appreciation which is felt within the Meteorological Office of the very helpful attitude shown by the Museum Director, and of the considerable effort which was made by his staff in the immediate fulfilment of the plan. An essential part of the plan was to secure, for as long a period as possible, an overlap of observations at the old Observatory site and the new Museum site. In this the Observatory staff who still remain at Greenwich have willingly co-operated, at the expense of personal inconvenience, particularly at week-ends and on public holidays, and after the meteorological observations have ceased to be of much value for purely Observatory purposes. Their full series of observations including hourly values ceased in May 1950, but the standard climatological records are at present still being maintained (August 1951).

As the Royal Observatory was established at Greenwich by Charles II in 1675 for the advancement of the science of navigation and nautical astronomy, it is very fitting, as the Museum Trustees and Director doubtless appreciated, that the continuation of a part of its work, near the original site, should be in the hands of the National Maritime Museum. It is equally appropriate that the Meteorological Office, having shared the fruits of the meteorological work of the Royal Observatory, should now become responsible for the equipment of the new station in the endeavour to prolong the record.

A. BLEASDALE

A Relic of the Royal Observatory, Richmond*

H.M. King George III built Kew Observatory for the purpose of rating his clocks and as a repository for the large collection of philosphical instruments which he and Queen Charlotte had collected, probably at the suggestion of Dr. Demainbray who had been scientific instructor to both before their marriage. It was finished in time for the observation of the transit of Venus on July 3, 1769.

When H.M. Queen Victoria decided to give up the Observatory in 1840, the collection was distributed to various interested authorities, the greater part

*According to the wording of the Catalogue.

of the scientific instruments being sent to the Curators of the Museum of King's College, London, with a request that the collection should be kept together and also used for instructional purposes.

The collection has now been lent by King's College to the Science Museum, South Kensington, for an indefinite period. At the suggestion of the authorities of both these institutions a manuscript catalogue relating to the collection, and hitherto located at Kew Observatory, has been made available for permanent preservation with the collection. This catalogue—" The Queen's Catalogue "—was presented by J. Rigaud, a great-grandson of Dr. Demainbray, to the British Association (then in control of Kew Observatory) in 1855. The catalogue, which relates to Queen Charlotte's contribution to the collection, lists 322 instruments (nineteen foolscap pages) and 76 presents received by the Queen from various people (four pages).

The Queen's Catalogue is described in detail in a paper by R. S. Whipple, " An old catalogue and what it tells us of scientific instruments and curios collected by Queen Charlotte and King George III ", published in the *Proceedings of the Optical Convention, London*, 1926, Part II.

The Director of the Science Museum has also in hand a printed account of the whole collection and the present whereabouts of the different parts of it, which will be available shortly.

Meteorological note on the Sudan haboob

In *Notices to Airmen* No. 8/51 dated March 29, 1951, the Sudan Government has brought to the notice of persons engaged in air navigation a meteorological note on the haboobs which occur in the Sudan from May to September. As the meteorological information given in this *Notices to Airmen* is of general interest it is reproduced below by kind permission of the Sudan Government Meteorologist:—

The term " haboob " is a very loose name which has been applied to a duststorm, either associated more or less *in situ* with one or more thunderstorms, or completely dissociated with the thunderstorm activity from which the duststorm is born.

Outrushing cold air from precipitating cloud of the cumulonimbus type may vigorously undercut the much warmer air of its environment, and the resulting violent ascent of air can quickly produce a " wall " of rising and blowing dust in advance of the storm clouds provided the soil surface is very loose. This state of affairs occurs from about late April or May onwards in the Sudan north of about the 13° N. parallel of latitude, and gives rise to the well known Sudan " haboob ".

In the early stages of its development, the duststorm is adjacent to the thunderstorm, but the dust " front " travels much quicker than the storm itself, and, provided the cold air supply and resulting gradient of pressure are maintained, may travel even some hundreds of miles before its energy is spent. It follows that the more vigorous the thunderstorm area, the more vigorous and intense the resulting duststorm. As the summer season progresses, however, the thunderstorm areas advance northwards, and, with the loose surfaces being bound together more firmly as the result of rain, the duststorms progressively become less intense in these areas.

In the Khartoum area the worst duststorms therefore occur early in the season (May and June), when the main thunderstorm activity is well to the south and the soil surface north of the 13°N. parallel initially very dry and loose. Later in the summer, thunderstorms are more prevalent in this area and the associated duststorms are less intense and much shorter-lived, though duststorms may be still severe to the north. Early-season duststorms usually last from 2 to 4 hours and in very exceptional cases much longer. Because they are the result of large-scale thunderstorm activity to the south, they normally occur after dusk. Late-season duststorms may only last some 5 to 15 minutes, and since they are usually directly associated with the thunderstorm(s), normally occur any time after midday.

Normal conditions associated with Sudan "haboobs" are as follows: Visibility is frequently reduced to well below 200 m. and the improvement is relatively slow in the early-season type of duststorm. Surface wind speeds may suddenly increase from zero to 25–40 kt. in a matter of seconds, and some initial gusts have been recorded of 50–60 kt. or above. A slow decrease of wind speed normally occurs after the first 30–60 min. The wind direction is initially from the south-easterly quarter in general, with a slow and steady veer towards the S. or SSW. with time. The dust tops are normally of the order of 2,000–3,000 m., very exceptionally to 3,500 m. or a little above. Turbulence is excessive at first decreasing slowly. Any rain falling through a duststorm improves visibility rapidly.

Phenomenally rapid rise in level of the River Euphrates

We are indebted to the Senior Meteorological Officer, R.A.F. Habbaniya, Iraq, for a note on a phenomenally rapid rise in the level of the River Euphrates in March 1950. The river at Habbaniya rose 8 ft. 6 in. in 48 hr. between March 10 and 12, 1950.

During the winter 1949–50 there were very heavy falls of snow in the Turkish mountains, and the primary cause of the rise in question seems certainly to have been the melting of this snow, assisted by rain falling over the Euphrates watershed in late February and early March 1950.

The river level would not have risen so appreciably in the 48 hr. in question, however, without two other factors operating in the source region of the river, namely rain and warmth; both these factors were in fact present. The weather situations which induced the snow to melt and which provided also additional rainfall were more especially the following:—

(*a*) 0000 G.M.T. February 21–1200 G.M.T. February 22. A low-pressure system over the eastern Mediterranean Sea and Jordania moved east, gave much rain over Turkey and marked rain-shower activity over the Levant, including thunderstorms over Syria.

(*b*) 1200 G.M.T. February 23. A depression over south-west Turkey moved east with much rain and many thunderstorms over the upper reaches of the river; by 0000 G.M.T., February 25, rain and thunder activity had almost ceased, although rain was reported in the Diyarbakir area until 0300 G.M.T. on February 26. This weather situation was complicated by a nearby active depression which was centred over the eastern Black Sea and the Caucasus Mountains and helped to cause an influx of warm air over central and southern Turkey.

(c) 0000 G.M.T. March 4. Heavy rain outbreak near Diyarbakir. Later that day, thundery activity over Jordania and Lebanon, and rain over Turkey which occurred intermittently until 0000 G.M.T. March 7.

No such rapid rise took place in the River Euphrates in the spring of 1951. The chief reason for this appears to have been the small amount of snow in the mountains around the source during the winter 1950–51. The crews of Turkish aircraft flying the route Ankara–Diyarbakir–Habbaniya remarked to the meteorological staff at Habbaniya that they have never known so little snow on the mountains.

Radio-telephone station at Great Dun Fell, Cumberland

The Ministry of Civil Aviation has recently installed a chain of twelve radio-telephone stations to provide communication between aircraft flying the new Civil Airways and Air Traffic Centres at Uxbridge, Preston and Prestwick. For technical reasons four of these stations are sited on the tops of mountains.

The photographs (between pp. 300–01) were taken at 1000 on January 16, 1951, during the installation and commissioning of the radio equipment at Great Dun Fell, 2,780 ft. above sea level, in the Pennines 14 miles from Penrith, Cumberland.

The station is the highest permanently manned post in the British Isles, and the road thereto is likewise the highest road, public or private.

The station is built on the site of a hut installed about 1938 by Prof. Gordon Manley for weather observation and a study of the local helm wind. Prof. Manley's experience and advice proved invaluable during the planning stages of this station, and his description of the conditions have been more than borne out.

The climatic conditions are similar to those of Iceland. The mountain top is almost permanently in cloud in winter. Wind velocities often exceed 100 m.p.h., and the temperature rises and falls rapidly above and below freezing point, sometimes several times in a day. Under bad conditions ice has been known to build up on masts and other structures at the rate of 1 in. in 20 minutes. Thaws are equally violent.

The staff of the station change watch every two days in winter. Deep snow blocked the road to a point below the 1,200-ft. level for much of the period from November to April last winter. At times the men were forced to climb through to the top on foot, a distance of four miles. The buildings were sometimes almost completely buried and a cutting had to be maintained down to the door.

The two 90-ft. towers shown in one of the photographs are of standard Air Ministry pattern, specially strengthened for the purpose. The 120-ft. wooden tower is the top half of a 240-ft. tower commonly used on radar stations during the war. The buildings are standard Ministry of Works type hut with double brick walls, double windows and insulated roofing.

" Across deep waters "

A documentary film " Across Deep Waters ", which has recently been released for public exhibition, shows something of the voluntary meteorological work carried out by the officers of British " selected " ships. The film is a pictorial

[*To face p.* 300

Reproduced by courtesy of D. C. Davies

BASE OF 120-FT. TOWER AT GREAT DUN FELL, CUMBERLAND, JANUARY 16, 1951

All the ice on the 120-ft. tower in the photograph fell off in a few hours, only to build up again later in the day.

To face p. 301]

Reproduced by courtesy of *Electronic Engineering* and D. C. Davies

GENERAL VIEW OF THE RADIO-TELEPHONE STATION AT GREAT DUN FELL, CUMBERLAND, JANUARY 16, 1951

(see p. 300)

record of a voyage from London to Montreal via Belle Isle of one of the "Beaver" cargo ships of the Canadian Pacific Steamship Company. During the course of the voyage an officer is shown making observations of sea-water temperature, barograph and hygrometer, and recording and coding the observations, and then the radio officer is shown transmitting the message. Later, the master and officer on watch are shown discussing a gale warning which has been received, and there are subsequently some very good sequences showing the ship under the influence of the gale.

It is pleasing to see this important voluntary work carried out by ships' officers, which has been done regularly aboard British ships since 1854, thus brought before the public.

C. E. N. FRANKCOM

Boletin Meteorologico

A new quarterly meteorological bulletin, published by the Ministerio de Agricultura e Industrias of Costa Rica, the first number covering the period January–March 1951 by months, has been received in the Meteorological Office Library.

Data are given from 50–51 stations, varying with the element.

The following tables are included:—Rainfall, monthly totals, number of days and maximum in a day; Temperature, monthly means, mean and extreme maxima and minima.

Additional information consisting of a tabulation of all rainfall, daily pressure, relative humidity and cloud observations is given for San José.

REVIEWS

Red Sea and Gulf of Aden. Oceanographic and meteorological data. Koninklijk Nederlands Meteorologisch Instituut. 21 in. × 17 in., pp. 26, *Illus.* Staatsdrukkerij-en Uitgeverijbedrijf, 's-Gravenhage, 1949. Price; *fl.* 10.

This Dutch meteorological and oceanographical atlas covers the sea area from Suez to longitude 52°E. The text is given in Dutch and English. The information is given in roses or figures in 1-degree squares. The number of observations is always provided. The data are all relevant Dutch ships' observations together with a small number of Swedish observations made before 1921. The total number of observations summarized is 482,245.

The contents are:—

(i) Monthly current and wind roses, vector mean winds and currents with constancy in both cases
(ii) Mean monthly surface air pressure and standard deviation
(iii) Air and sea-surface temperature
(iv) Percentage frequency of gales
(v) Percentage duration of "fog" and "dust fog"
(vi) Notes on the occurrence of tropical storms in the Gulf of Aden
(vii) Table of occasions on which a current drift exceeding 73 sea miles in 24 hours was noted.

The charts are beautifully printed and very clear. The use of 1-degree squares, however, produces mean values for many squares off the main shipping route based on very few observations. Thus, the wind rose for April in the

square of " origin " 17°N., 40°E. is based on 1,579 observations while one in the square immediately to the west is based on only 54 observations.

There is generally satisfactory agreement between this Atlas and British publications. The percentage frequencies for fog, small as they are, are rather higher than those in the naval handbooks* and raise doubt as to whether they refer strictly to visibility less than 1 Km. There is some disagreement with the " Monthly meteorological charts of the Indian Ocean " in gale frequencies which it is surmised may be due to the Dutch service having calculated them for force 8 or over against the British practice of force 7 or over.

G. A. BULL

The climate near the ground. By Dr. Rudolf Geiger. Translated by Milroy N. Stewart and others. 8½ in. × 5¾ in., pp. xxii+482, *Illus.*, Harvard University Press, Cambridge Mass., Geoffrey Cumberlege, London, 1951. Price: $5.00 or 32*s.* 6*d.*

The first edition of the book entitled " Climate of the air layer near the ground ", by Dr. Geiger of the University of Munich, was published in 1927, and has long since been regarded as a classic in that it succeeded in presenting a first-class survey of microclimatological problems and in consolidating into one book the results of widespread research and investigation hitherto available only in disjointed papers and reports.

During the succeeding decade considerable progress was made in this important branch of meteorology not only by meteorologists themselves but also by scientists dealing with allied subjects such as agriculture, medicine and industrial design. A complete revision of the original book was therefore necessary and was completed by the author in 1941. The translation into English was undertaken in America at the end of the war, and shortly before completion it was learnt that a third edition was in course of preparation in Germany. Dr. Geiger consented to supply additions to the second edition so that the present book is the virtual equivalent of the third German edition.

The method of presentation of the subject matter is admirably planned, a factor of great importance when dealing with so complicated a science. The influence that the ground exerts on the climate of the air layer of the first two metres is explained in the first section. In particular the many methods by which heat moves to and from level ground is discussed. The heat exchanges at midday and midnight are examined in general terms, and the roles played by conduction, eddy diffusion and radiation are clearly dealt with. The second section deals with temperature relationships near the ground, explained as consequences of the general principles laid down in the previous section. After discussing the warming process and the cooling process the diurnal and annual course of temperature and temperature gradient are examined and reference therein is made to the researches of N. K. Johnson, A. C. Best and W. D. Flower of the British Meteorological Office, with quotations of the results obtained from the experiments on Salisbury Plain and Ismailia (Egypt). The third section deals with the behaviour of other meteorological elements near the

*London, Meteorological Office. Weather in the Mediterranean, Vol. II, Part 12, Red Sea. London, 1936.
London, Meteorological Office. Weather in the Indian Ocean, Vol. II, Part 2, The Gulf of Aden and west Arabian Sea to longitude 60°E. London, 1944.

ground—humidity, wind, visibility, dust and optical phenomena. Finally, the fourth section of the first part considers the significance of the type of ground and its influence on the microclimate. The earth's surface can be soil of different texture, colour or degree of moistness, grass, brick, concrete or stone, shallow or deep water, ice or snow, and each type of surface has a different effect on the climate of the nearby air.

Part II of the book deals with the influence of topography, vegetation and buildings on meteorological elements in the surface layer of air which may, on occasion, exceed the imposed limit in height of 2m. stipulated in Part I. The first section in this part, section five, considers topography. The pooling of cold air, valley temperatures, up-slope and down-slope winds, the effect of slope on sunshine and consequent microclimate and the general influence of land configuration are treated in the successive chapters. Finally, the range of validity or representativeness of a meteorological station is analysed, and a supplementary chapter deals with the microclimate of caves. Section six considers the influence of plant cover. Plants with their peculiar heat and water economy exercise a considerable effect on the climate and microclimate in which they live, and such effects vary with different crops and different stages of growth. So important is this aspect of the general subject that it is often given other names such as ecoclimate. The influence can grow with increasing size and extent of plant cover so as to affect the general climate or macroclimate of a large region. First, the heat economy of plants, their temperatures and radiation balance are considered, then humidity and wind relationships. Further chapters in this section deal with the meteorology of forests and large stands of trees, considering the radiation, temperature, humidity and rainfall, thence the influence of clearings within a dense forest and the end effects of the forest border. Section seven deals with the relation of living creatures, including man, to the microclimate. Small insects and animals depend for their whole being on the existence of suitable living conditions. Their existence or absence provide excellent indicators and integrators of climatic conditions. Man, on the other hand, either consciously or unconsciously tends to change the climate in which he lives, both by the building of houses and factories and by the creation of cities. As examples of conscious change in climate we have the erection of shelter against the wind and methods of heating to combat frost.

With such a wide range of subjects it is obvious that considerable pruning and compression were necessary to produce a book of less than 500 pages. In fact almost every chapter could with no difficulty at all be expanded into a book or volumes of books of valuable subject matter. It is therefore particularly praiseworthy that at least 50 pages are devoted to an extensive bibliographical list of references, and even then many of the references are specially chosen because they contain further references covering one particular aspect of the subject; in this way, 1,200 other works have been included without specific mention. This admirable feature provides not the least important service of the publication. In comparison, the index of subjects seems too small when one considers the wealth of subject matter. The printing is of a high standard although there are occasional lapses, such as an incorrect heading at the top of p. 193 and the wrong sign in the formula on p. 60. The diagrams are clearly reproduced and well annotated; most of them are self-explanatory

and only a few need a careful reading of the accompanying text before their import becomes clear. Some of the theories and supporting arguments are perhaps to be regarded as summaries of the problem rather than final undisputed explanations. The translation is essentially readable, the introduction of occasional colloquial phrases avoiding the stilted impression so often present in scientific translations.

Of the subject itself, it is difficult to overpraise its importance. Climatologists, for the most part, have been driven by force of circumstances and a need for comparable uniformity to deal with an artificial standard " screen " climate. This in itself is the essential first step to obtain knowledge of the microclimate. The present book is an unsurpassed attempt to make further steps towards a complete knowledge of the more real and vital realm of macroclimate. The working synoptic meteorologist engaged mainly in the production of aviation forecasts will find much in the book which will improve his knowledge and appreciation of the vast science of meteorology. To any scientist who is concerned with the important task of applying his skill to the fundamental problems of life and growth the book is invaluable. Both praise and thanks are due to the author for accomplishing the immense work of summarizing the existing knowledge into so small a space, also to the translators who have made available such a wealth of information to the English-reading scientific world.

L. P. SMITH

BOOK RECEIVED

Report on the administration of the Meteorological Department of the Government of India in 1949–50. $6\frac{1}{2}$ in. $\times 9\frac{1}{2}$ in., pp. ii+62, *Illus.*, India Meteorological Department, Delhi, 1951.

OBITUARY

Inspecteur-Général E. Delcambre.—We regret to learn of the death at Denée (Maine-et-Loire) in his 79th year of Général Delcambre. During the first war he was head of the meteorological service of the French Army and, in that capacity, many officers of the British Army Meteorological Section came to know him and to appreciate his vigorous kindly manner. He succeeded M. Angot as Director of the Office National Météorologique de France on November 25, 1920, and held this post until June 30, 1934. During these years he was well known as a member of the International Meteorological Committee and of several Commissions of the International Meteorological Organization. On September 14, 1923, he succeeded Sir Napier Shaw as President of the International Commission for the Study of Clouds and was still President when that Commission was dissolved in 1946. It was this commission that published in 1932 the now familiar " International Cloud Atlas " which replaced the older atlas of 1896; Général Delcambre wrote the Preface to this new Atlas.

Of wide meteorological interests he was President of the Société Météorologique de France and held the office of Secretary-General of the Society from January 1926 until his retirement in 1934. During all this period he and the Office National Météorologique helped the Society considerably, particularly in the early days when it was still suffering from the after effects of the first war.

Whilst he was Director, Général Delcambre wrote two parts of the " Cours de météorologie " which was published by the Office National Météorologique in 1926, Part I, " Instruments et procédés d'observations météorologiques " and Part III, " Sondages aerologiques ". He wrote many articles

for *La Météorologie*, the first number of which appeared in 1925 when he was President of the Société National Météorologique, including some on the co-operation necessary between meteorologists and agriculturalists. In 1931 he wrote " L'organisation de la protection météorologique sur l'Atlantique ", in which he suggested the establishment of " stations flottantes internationales " (or ocean weather stations to use the modern term); the cost of each he calculated at $24,000 a year and he suggested the use of sailing ships with auxiliary motors. In 1934 the lecture " Les dictons populaires et la prevision du temps ", which he had given the previous year at Brive, was published in *La Météorologie*. This was illustrated with woodcuts and reproductions of pages from old books.

METEOROLOGICAL OFFICE NEWS

Hurricane in Jamaica.—The Meteorological Office in Jamaica was wrecked and all communications dislocated when the centre of a hurricane passed just south of Palisadoes Airfield at 2215 E.S.T. on August 17, 1951.

The wind exceeded 100 kt., the lowest pressure was 973 mb. (recorded by barograph) and more than 430 mm. of rain fell.

News has been received that all members of the Meteorological Office Staff are safe.

Move of the Training School to Stanmore.—During its relatively short history the Meteorological Office Training School has had its full share of moves. Croydon, Gloucester, and various districts of London have at different times housed the new entrants to the Office. After four-and-a-half years in Kingsway, in the centre of London, the School has moved once more, this time to Stanmore on the north-west outskirts of London.

At Stanmore, the School is accommodated in a plain single-storeyed building in pleasant surroundings. From a technical point of view Stanmore enjoys many advantages over central London, not least of these being a clearer atmosphere. In visibility points, however, Kingsway enjoys an overwhelming advantage. Visibility objects, viewed from the roof of Princes House, ranged to a distance of 18 miles and included such notable landmarks as St. Paul's Cathedral, Nelson's Column, and the Houses of Parliament, guides to English history as well as to the measurement of atmospheric obscurity.

Ocean weather ships.—A special air/sea rescue exercise was carried out in the Firth of Clyde by the ocean weather ships *Weather Explorer* and *Weather Watcher* on July 18, assisted by an aircraft of R.A.F. Coastal Command.

The aircraft approached the ship and was brought down from 3,000 to 100 ft. by radar control. The ship laid a smoke path, dummies representing survivors were dropped by the aircraft for each ship in turn and the dummies were satisfactorily recovered by the ships' lifeboats and other means. A new immersion suit for assisting the " survivors " out of the water was used for the first time with great success. Representatives of the Ministry of Civil Aviation, B.O.A.C. and R.A.F. Rescue attended.

Exhibitions.—The Marine Branch exhibit " The Gale Warning Story ", which consists of 18 original oil paintings by Mr. C. A. Jupp with appropriate explanatory captions, was shown to the Meteorological Association at Harrow on June 30, to the " Shipping and Industries Exhibition " at Southampton,

July 7–14, and to the "Daylight on Industry Exhibition" at Liverpool, July 23 to August 14.

Notices in the Southampton and Liverpool press show that the exhibit created considerable public interest on account of its original treatment in tracing the evolution of gale-warning methods from 3000 B.C. to the world-wide system of the present day.

Examination successes.—We offer congratulations to the following on their recent successes:— Mr. J. C. Ascough and Mr. T. Kelly, who have obtained the degree of B.Sc. General (London) in physics and mathematics; Messrs. J. M. Beckley, J. G. D. Beimers, J. A. Clements, L. Dent, G. Douglas, R. A. Ebdon, N. Ellis, A. Gray, G. N. Groves, P. Horsley, A. R. May, who have passed the Intermediate B.Sc. examination of London University.

Horticultural Show.—The Office staff were amongst the prizewinners at the Summer Show of the Air Ministry and Ministry of Civil Aviation Horticultural Society held at Adastral House on July 17: Mr. B. G. Brame (fruit, vegetables and flowers); Miss H. G. Chivers (flowers); Mr. N. E. Davis (vegetables); Mr. H. A. Scotney (vegetables and flowers) and Miss D. J. Wordsworth (flowers). Between them they carried off 25 prizes, including 7 firsts.

Sport.—Mr. S. W. Lewis gained second place in the Civil Service Mile Swimming Championship held at Tooting Bec on July 12, 1951: an excellent performance for so young a member of the staff.

WEATHER OF AUGUST 1951

Mean pressure was above 1015 mb. over a large area extending from north-west Canada south-eastwards to Florida and across the Atlantic covering most of south-west Europe and also parts of central Europe. In an area extending westward of and including the Azores, mean pressure was above 1025 mb. Between northern Scotland and southern Iceland mean pressure was below 1005 mb.

The mean pressure was slightly below normal over the United States and above normal over Canada especially east of the Rockies in Alberta. The British Isles had a deficit of about 5 mb., this area extending to southern Iceland. Over the rest of Europe pressure was also below normal excepting in Scandinavia where it was slightly above and in Finland where it was more than 5 mb. above. The Azores high was further north than usual and this gave an area with pressure above normal in mid Atlantic.

Mean temperature was generally above normal in eastern and northern Europe (including Scandinavia) and in the southern United States. Finland experienced an excess of more than 5°F. while the north coast of the Gulf of Mexico was about 5°F. above normal. Temperatures were generally below normal in south-western Europe (except parts of Spain) and in north-western Canada which had a deficit of 5°F. in places. Mean temperature was just below 100°F. inland over the Sahara and in southern Iraq.

In the British Isles the weather was unsettled and wet, excessively wet in parts of the eastern and central districts of Great Britain. It was rather dull and mainly cool, a feature of the month being the absence of any very warm spells.

In the opening days depressions moved north-east along our north-west seaboard while associated troughs crossed the British Isles. Scattered showers occurred in Scotland and Ireland on the 1st and rain, heavy locally, fell in the west and north on the 2nd, but fair, warm, sunny weather persisted over much of England. The rain spread to most parts of England on the 3rd but did not reach eastern districts until nightfall. Temperature rose to 80°F. locally in eastern districts of England on the 2nd and 3rd and touched 82°F. at Southend on the 2nd and at Hull on the 3rd. From the 5th to the 7th a depression off the south-west of Ireland moved slowly south-east to Brittany and then turned north and filled, while another centre developed over France and moved north over the eastern districts of Great Britain reaching the extreme north-east of Scotland by the morning of the 8th. Heavy rain occurred in the south-west on the 5th and widespread heavy rain, with local thunderstorms on the 6th–7th (2·62 in. at Ashburton, Devon, on the 5th and 2·48 in. at Birdsall Gardens and Burton Pidsea, both in the East Riding of Yorkshire, and 2·42 in. at Connington Castle Gardens, Huntingdonshire, on the 6th). On the 8th another depression off the mouth of the English Channel moved east over France and later turned north to the Low Countries. Rather scattered rain was recorded on the 8th and local rain and thunderstorms occurred in England on the 9th. On the 11th and 12th a depression off south-west Ireland moved east-north-east to the North Sea and was associated with considerable rain in England on the 11th (2·33 in. at Compton, Sussex) and showery weather generally on the 12th and 13th. Subsequently a pronounced wedge of high pressure crossed the British Isles and maintained mainly fair weather on the 14th and 15th. Thereafter unsettled conditions were resumed with low pressure south of Iceland and troughs crossing the British Isles. Rain fell in most parts and was considerable locally on the 16th, 18th and 21st. On the 23rd and 24th a small secondary off south-west Ireland moved north-east to the North Sea and was associated with moderately heavy rain in places on the 23rd and slight rain or showers on the 24th. On the 25th a deep depression south of Iceland moved south-east to a position off north-west Ireland and gradually became less deep. Meanwhile troughs or secondary depressions associated with it moved over the British Isles and maintained unsettled weather, with heavy rain at times, until the end of the month (2·36 in. at Ystalyfera, Glamorgan, on the 25th, 2·41 in. at Ilfracombe on the 26th, 2·06 in. at Oakley Quarries, Merioneth, on the 28th and 2·43 in. at Cowes Water Works, Isle of Wight, on the 30th). Thunderstorms occurred locally on some days, for example, on the 26th–27th, 30th and 31st; they were rather widespread on the 31st.

The general character of the weather is shown by the following provisional figures:—

	AIR TEMPERATURE			RAINFALL		SUNSHINE
	Highest	Lowest	Difference from average daily mean	Percentage of average	No. of days difference from average	Percentage of average
	°F.	°F.	°F.	%		%
England and Wales ...	82	35	−1·0	156	+3	91
Scotland	75	30	−0·7	125	+2	89
Northern Ireland ...	71	44	−0·7	111	+5	97

RAINFALL OF AUGUST 1951

Great Britain and Northern Ireland

County	Station	In.	Per cent. of Av.	County	Station	In.	Per cent. of Av.
London	Camden Square	3·66	166	*Glam.*	Cardiff, Penylan	4·59	[illegible]
Kent	Folkestone, Cherry Gdn.	5·46	229	*Pemb.*	Tenby	5·90	[illegible]
"	Edenbridge, Falconhurst	5·44	208	*Card.*	Aberystwyth	...	[illegible]
Sussex	Compton, Compton Ho.	7·94	257	*Radnor*	Tyrmynydd	5·63	[illegible]
"	Worthing, Beach Ho. Pk.	4·14	183	*Mont.*	Lake Vyrnwy	7·23	[illegible]
Hants.	Ventnor	4·08	200	*Mer.*	Blaenau Festiniog	11·00	[illegible]
"	Bournemouth	4·14	164	*Carn.*	Llandudno	3·40	[illegible]
"	Sherborne St. John	4·61	190	*Angl.*	Llanerchymedd	4·83	[illegible]
Herts.	Royston, Therfield Rec.	4·25	165	*I. Man*	Douglas, Borough Cem.	5·05	[illegible]
Bucks.	Slough, Upton	3·10	143	*Wigtown*	Port William, Monreith	4·35	[illegible]
Oxford	Oxford, Radcliffe	3·67	161	*Dumf.*	Dumfries, Crichton R.I.	5·66	[illegible]
N'hants.	Wellingboro' Swanspool	3·99	168	"	Eskdalemuir Obsy.	7·15	[illegible]
Essex	Shoeburyness	2·27	128	*Roxb.*	Kelso, Floors	2·61	[illegible]
"	Dovercourt	3·61	202	*Peebles*	Stobo Castle	4·69	[illegible]
Suffolk	Lowestoft Sec. School	2·28	104	*Berwick*	Marchmont House	3·70	[illegible]
"	Bury St. Ed., Westley H.	3·41	131	*E. Loth.*	North Berwick Res.	3·87	[illegible]
Norfolk	Sandringham Ho. Gdns.	3·59	133	*Midl'n.*	Edinburgh, Blackf'd. H.	5·27	[illegible]
Wilts.	Aldbourne	4·30	162	*Lanark*	Hamilton W. W., T'nhill	5·03	[illegible]
Dorset	Creech Grange	6·03	211	*Ayr*	Colmonell, Knockdolian	5·55	[illegible]
"	Beaminster, East St.	5·81	186	"	Glen Afton, Ayr San.	8·42	[illegible]
Devon	Teignmouth, Den Gdns.	3·61	160	*Bute*	Rothesay, Ardencraig	4·69	[illegible]
"	Cullompton	5·00	164	*Argyll*	Morvern (Drimnin)	6·01	[illegible]
"	Ilfracombe	8·34	232	"	Poltalloch	4·21	[illegible]
"	Okehampton Uplands	5·81	137	"	Inveraray Castle	6·75	[illegible]
Cornwall	Bude, School House	4·48	159	"	Islay, Eallabus	3·91	[illegible]
"	Penzance, Morrab Gdns.	4·88	154	"	Tiree	4·11	[illegible]
"	St. Austell	5·09	141	*Kinross*	Loch Leven Sluice	3·96	[illegible]
"	Scilly, Tresco Abbey	4·96	180	*Fife*	Leuchars Airfield	2·94	[illegible]
Glos.	Cirencester	5·31	177	*Perth*	Loch Dhu	8·94	[illegible]
Salop.	Church Stretton	3·80	114	"	Crieff, Strathearn Hyd.	5·60	[illegible]
"	Shrewsbury (Monksmore)	3·24	117	"	Pitlochry, Fincastle	6·24	[illegible]
Worcs.	Malvern, Free Library	3·78	131	*Angus*	Montrose, Sunnyside	3·81	[illegible]
Warwick	Birmingham, Edgbaston	4·24	156	*Aberd.*	Braemar	4·33	[illegible]
Leics.	Thornton Reservoir	5·07	181	"	Dyce, Craibstone	3·96	[illegible]
Lincs.	Boston, Skirbeck	3·51	147	"	Fyvie Castle	3·93	[illegible]
"	Skegness, Marine Gdns.	4·06	166	*Moray*	Gordon Castle	3·50	[illegible]
Notts.	Mansfield, Carr Bank	4·82	173	*Nairn*	Nairn, Achareidh	4·07	[illegible]
Derby	Buxton, Terrace Slopes	5·32	121	*Inverness*	Loch Ness, Garthbeg	6·83	[illegible]
Ches.	Bidston Observatory	5·04	164	"	Glenquoich	10·36	[illegible]
Lancs.	Manchester, Whit. Park	4·42	128	"	Fort William, Teviot	7·52	[illegible]
"	Stonyhurst College	5·27	104	"	Skye, Duntuilm	3·56	[illegible]
"	Squires Gate	4·06	119	*R. & C.*	Tain, Tarlogie House	4·57	[illegible]
Yorks.	Wakefield, Clarence Pk.	4·27	164	"	Inverbroom, Glackour	5·21	[illegible]
"	Hull, Pearson Park	5·31	182	"	Applecross Gardens	6·40	[illegible]
"	Felixkirk, Mt. St. John	5·56	195	"	Achnashellach	7·02	[illegible]
"	York Museum	5·74	228	"	Stornoway Airfield	3·07	[illegible]
"	Scarborough	6·23	224	*Suth.*	Loch More, Achfary	5·60	[illegible]
"	Middlesbrough	5·73	209	*Caith.*	Wick Airfield	2·97	[illegible]
"	Baldersdale, Hury Res.	3·22	92	*Shetland*	Lerwick Observatory	5·33	[illegible]
Norl'd.	Newcastle, Leazes Pk.	4·87	173	*Ferm.*	Crom Castle	4·89	[illegible]
"	Bellingham, High Green	3·49	99	*Armagh*	Armagh Observatory	4·47	[illegible]
"	Lilburn Tower Gdns.	3·52	125	*Down*	Seaforde	4·15	[illegible]
Cumb.	Geltsdale	3·47	84	*Antrim*	Aldergrove Airfield	3·56	[illegible]
"	Keswick, High Hill	5·44	104	"	Ballymena, Harryville	4·94	[illegible]
"	Ravenglass, The Grove	6·16	135	*L'derry*	Garvagh, Moneydig	4·83	[illegible]
Mon.	Abergavenny, Larchfield	3·82	128	"	Londonderry, Creggan	3·53	[illegible]
Glam.	Ystalyfera, Wern House	11·94	193	*Tyrone*	Omagh, Edenfel	5·13	[illegible]